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ALPHABET OF GEOLOGY.



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ALPHABET OF GEOLOGY

AND

Elements of Mineralogy.

A TREATISE

DESIGNED FOR STUDENTS AT SCHOOL OR AT HOME, AND ESPECIALLY ADAPTED TO THE ADVANCED CLASSES OF THE COMMON SCHOOLS.

ACCOMPANIED BY

MINERAL SPECIMENS

OF MOST OF THE

Great Masses of Rock that Compose the Globe.

By H. T. W. ADAMS.

SPRINGFIELD, MASS.:
SAMUEL BOWLES & COMPANY.
1868.

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PREFACE.

THAT *Geology* and *Mineralogy* are neglected sciences, and that the people ought to have a better knowledge of them, cannot be questioned. In our high schools and academies, studies of less value are taught. This little Manual will contain, in a condensed form much that is elaborately spread out in other works. The author has labored to arrange the material so as to confine the attention step by step, that the whole may be understood; and it is hoped that the present plan of instruction will be so attractive, that the teachers and pupils will be often led to the fields and to nature's wild haunts, where they will need no calisthenic exercises but such as are required for the use of hammers and chisels; *and if it be summer time,* baskets for flowers.

Believing if a taste is formed for the *natural sciences,* life will be made happier and more useful, leading to life's great end, we submit this outline of a science which ranks next to astronomy, to an enlightened public, hoping and trusting that the great Author of worlds will add His blessing so to the young minds that they may see God in His works, and loving Him through the works of His beautiful creations, will be led to draw near unto Him, who speaks in the grandeur of the upheaved mountains, as well as in the sweet voices of nature's whisperings, saying, "Come unto me."

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INTRODUCTION.

THE climate, soil and productions of the different countries are so varied, that we naturally expect the rocks to differ, but we find wonderful uniformity everywhere. We find the upheaved granite and all other primary rocks the same in Europe, Asia and Africa, as in America; and the deposits of the precious metals are about equally accessible to all the inhabitants of the globe; iron, coal and the other useful minerals are very abundant.

Geology aids the skill and industry of all classes. A knowledge of the rocks enhances the enjoyment and lightens the toil of the artisan as he chisels his stony material; and the time will undoubtedly come when the farmer will be considered degraded who knows not the composition of the rocks and soil of his farm. Besides, if he has a knowledge of Geology and there be mineral treasure under the soil, he will be more sure to find it.

Geology had its origin as a science in the eighteenth century. It was attacked by misguided philosophers, but it now stands upon a firm basis. Its noblest efforts are to deduce from existing appearances what produced them. On seeing a formation composed of fossil shells and fishes, it will be suggested to the thinking mind that they must have been deposited beneath salt water, and that rounded pebbles and boulders were rolled by waves of ocean or by

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running streamlets or rivers; and by examining the cliffs, wells and excavations we learn the thickness of the formation. We also learn that the stratified rocks have a regular order and may be classed, by attention to their mechanical and chemical constitution, and the organic remains they contain. The non-stratified rocks, having no order or place, may be found with aqueous deposits of all ages. A bed or stratum occupying a particular place in the series may be in one place a clay, and in another a limestone; but the fossils being the same, there will be no difficulty in identifying one with the other, and if the deposits of the ancient seas were like those of the present time, in some places the formation may be entirely wanting. When we see the strata *conformable* like the leaves of a book, and other formations lying *unconformably* upon the upturned edges, we conclude that the upheaving took place before the other rocks were deposited. And when we observe that the layers of a formation are the same on the opposite sides of a mountain, forming a foliated axis, we believe a force from beneath bent the strata upward.

Geologists have divided stratified rocks into ten groups, nine of which are fossiliferous, the lowest in the series being *graywacke* and argillaceous slates. This group includes slates and transition limestone. The *carboniferous* group lie next above, and contain old red sandstone, mountain limestones and the coal measures; next, red sandstone, and so on up to alluvial. The mind possesses a classifying principle—a law of order and arrangement. Nature presents this necessity in her varied outward forms and inner structure. Plants, animals and minerals, and the starry heavens present differences which the mind seizes and remembers. These memories lay a foundation upon which to build up a structure of knowledge

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which shall be in the mind a temple of great beauty, and a mine of wealth to its possessor.

In the lowest fossiliferous rocks we do not find vegetable, but animal life secreting the limestone, and preparing, by their animal remains, a soil upon which the future vegetation shall live. In the beautiful chambered shells we trace as it were, the finger-marks of Omnipotence, and in the organic masses we see truth, beauty and purity impressed, and rainbow tints in the crystal gems.

To the Divine Will we refer all first causes in geology.

To the Christian student its claims are of the highest order. It elevates the mind and brings the heart in sympathy with every created being. The more we study His works, the more we see the wisdom and benevolence of the Creator. The Christian loves his Bible; it is God's *new* and revealed *book*. The rocks are His *old book*, and not less truly revealed. In its strata are its pages lettered as with a diamond, and he who has learned to love the Creator, and will read His revealed Will prayerfully, will see that the two *books* are in conformity; he will find no discrepancies.

'Tis God in the volcanic throes,
And in the zephyr's sigh;
'Tis God where sleep the living things,
Impressed long ages by.

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GUIDE TO TEACHERS.

A GOOD microscope is essential as it will interest the pupils in their rambles, and aid the teacher in judging of the specimens.

The little boxes of specimens being present, let each pupil be required to show which three specimens of simple mineral form *granite.* The pupil will then take from the box, quartz, mica and felspar. Then let the pupils be required to show which specimens form *syenite.* They will then show from their boxes *hornblende,* and placing it with the *quartz* and *felspar* they have the simple minerals that compose *syenite.* Then let them show which two simple minerals form *mica slate,* (mica and quartz). Then let them tell the difference between limestone and gypsum,—the one being a carbonate, the other a sulphate of lime: limestone having carbonic acid; gypsum, sulphuric acid. Then the difference between pudding-stone and breccia, etc., etc.

Pudding-stone has rounded fragments or pebbles, united by iron or other cement. Breccia has angular fragments united or cemented, and is called by geologists metamorphosed rock, and conglomerate when the materials are very coarse. The ingredients of pudding-stone often become angular when broken.

The description of the minerals in the boxes and others that represent the great masses of rock on the globe will be found on

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the first pages of the book, and the chemical analysis, or the simple elements of which the minerals are composed, should be committed to memory. The exact proportions are omitted as the young minds should not be overburdened.

The crystals of sulphuret of iron (fool's gold,) may be easily explained, as they generally crystallize in cubes or octohedrons,—being twenty-eight parts iron, and sixteen parts sulphur. The teacher may explain the cube by a small square block, and one form of the octohedron by two pyramidal blocks, placing the bases together. Mineralogists give ten shades to quartz rock, and many shades to other minerals. Two or more shades of quartz and lime will be given in the boxes. A drop of acid will distinguish limestone. The pupils should learn that different varieties of the same minerals may be *opake*, showing no light,—*translucent* as china, or *transparent* as glass. Alabaster is translucent, and crystals of quartz are transparent.

The minerals essential to the study of geology will be found in all the boxes. All the common stones are represented, and by a little practice in breaking those found everywhere, the student will soon learn which is lime and which quartz, although the color may not be so beautiful a shade as those in the boxes. Sand and other ingredients often make the specimen more imperfect. We hope to have those in the boxes as free from foreign ingredients as possible, and good specimens of the rock which they represent. Geologists apply different names to the same mineral as sulphuret of iron (pyrites) (fool's gold.) The glossary should often be consulted as minerals and gems found in the United States are described, also scientific terms found in Geology and Mineralogy are defined in it.

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ALPHABET OF GEOLOGY.

CHEMISTRY.

[The pupil must learn a little of chemistry before answering questions in geology.]

Q. What is a simple substance?

A. Something that is *not* combined or united with anything else.

Q. Will you name some simple substances?

A. Sulphur, charcoal, (carbon,) and iron.

Q. Will you name some simple gases?

A. Oxygen, nitrogen, hydrogen.

Q. When these substances unite with each other, or with other substances, what do they form?

A. Compounds, either simple or complicated.

Q. When two, three or four gaseous or other substances unite, what are the compounds called?

A. A binary, a triple, a quadruple compound, etc.

Q. What is the difference between a simple chemical union and a mixed or cemented compound?

A. By a simple chemical union, an entire new substance is formed, but in a mixed union the materials are not changed.

Q. Will you give examples?

A. Oxygen and hydrogen when burned together form *water*, a new substance. Mica united with quartz, form *mica-slate*, simply adhering.

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Q. Will you name some complicated or mixed compounds which are triple and quadruple?

A. Pudding-stone, breccia and granite. The atmosphere is also a mixed compound of oxygen, nitrogen and carbon.

Q. Carbon is poisonous to the lungs of animals; then why is it added to the atmosphere?

A. That plants may breathe it and live and become food for animals.

Q. What minerals contain carbon?

A. Coal, limestone, marble and many other rocks. Vegetables also contain carbon; charcoal is nearly all carbon, and the diamond is a pure crystal of carbon.

Q. When carbon is chemically combined with oxygen, what is formed?

A. Carbonic acid gas—a binary compound—found in the air, and sometimes in old wells and caverns.

GEOLOGY.

Q. What is the meaning of the word geology?

A. It means a discourse about the earth.

Q. What are the largest divisions of the science of geology?

A. Earth, air, and water, comprising all the material of planet Earth. The same materials that form air and water enter largely into the composition of the rocks that form the Earth's crust.

Q. Into what different formations are the rocks divided by geologists?

A. Primary, lowest. Transition and secondary next; 3d Tertiary; 4th Drift; 5th Alluvial and Surface Soil.

Q. What agencies assist in decomposing and dissolving the surface of the rocks?

A. The atmosphere, vapor and currents of water.

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Q. What other agencies have affected changes in the rocks during ages past?

A. Heat (caloric,) cold, light and electricity.

SIMPLE EARTHY MINERALS.

Q. What simple minerals enter into the great masses of rocks that forms mountains?

A. Quartz, felspar, mica, hornblende and augite, limestone, talc, serpentine and oxide of iron.

You may now take these eight minerals from the box and tell of what tangible and of what gaseous substances each simple mineral is composed, beginning with quartz (silica) (silex).

A. Quartz is composed of silicon and oxygen.

Chemists reduce silica to a brown powder called *silicon*—but when exposed to the air it becomes silica.

Sand, sandstone, quartz and flint are all nearly pure silex, (silica) quartz crystal is pure silex.

Q. Where does silica exist abundantly?

A. In the soil; also in the ashes of all plants, especially grasses.

Q. Can it be dissolved?

A. It can only be dissolved by the alkalies, such as potash and soda with which it forms glass.

Q. How much of the earth's crust is silica?

A. One-half.

Q. What more can be said of silica?

A. It is a non-conductor of electricity and some suppose it to be an acid.

Q Of what is felspar composed?

A. Silica, alumina, potash or soda.

Q. Of what is mica composed?

A. Silica, alumina, potash and magnesia.

Q. Of what is hornblende composed?

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A. Of silica, lime, magnesia, oxide of iron and manganese.

Q. Of what is augite composed?

A. Of nearly the same as hornblende.

Q. Of what is serpentine composed?

A. Silica, water, magnesia, lime, alumina and oxide of iron. It is usually half magnesia.

Q. Of what is talc composed?

A. Of water, silica, potash, magnesia, and oxide of iron.

Q. Of what is oxide of iron composed?

A. Of oxygen and iron.

Q. Of what is limestone composed?

A. Of lime, (calcium) and carbonic acid.

Q. Of what is gypsum composed?

A. Of lime, (calcium) and sulphuric acid.

Q. Of what is iron pyrites (fool's gold) composed?

A. Of iron and sulphur.

Iron often exists in large masses. Iron Mountain in Missouri is three hundred feet high and two miles in circumference.

MIXED COMPOUNDS.

[The pupils will show the specimens when describing the compounds.]

Q. Of what three minerals is granite formed?

A. Quartz, felspar and mica. Gneiss has the same.

Q. When is gneiss called protogine or talcose gneiss?

A. When talc takes the place of mica.

Q. What three simple specimens make *syenite?*

A. Quartz, felspar and hornblende.

Q. What four compose *syenitic granite?* (Quincy granite)?

A. Quartz, felspar, hornblende and mica.

Q. Which two compose *mica slate* (schist)?

A. Quartz and mica.

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Q. Which two compose *talcose slate?*

A. Quartz and talc.

Q. Describe coarse granite.

A. Granite is called coarse when the quartz, felspar and mica can be seen with the naked eye—in chunks or blocks.

Q. When is granite called *eurite?*

A. When the granite is fine and crystalline.

Q. What is graphic granite?

A. It is quartz and felspar—the quartz appearing like letters.

Q. When is granite porphyritic?

A. When the felspar is crystalline and more conspicuous than the other materials.

Q. What was ancient porphyry?

A. It was fine compact felspar with imbedded crystals of the same material.

Q. Can porphyry be formed of any other rock?

A. Yes, the base may be of basalt, greenstone, pitchstone, trachyte, clinkstone, &c., with crystals of felspar.

Q. What minerals compose *greenstone?*

A. Felspar, hornblende or augite.

Q. How is *greenstone* distinguished from granite?

A. By the absence of quartz and mica and by the predominance of hornblende or augite.

Q. What is trachyte?

A. It is composed of augite, felspar, mica and iron. It is usually of a light gray color but when hornblende takes the place of augite its color is very dark.

Q. What more can be said of trachyte?

A. It belongs to the tertiary formation and is of volcanic origin. It is not abundant in the United States but is found in South America and composes the loftiest summits of the Cordilleras in Mexico.

Q. What minerals are called trap rock?

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A. Greenstone, basalt, augite, wacke and some varieties of porphyry.

Q. What is amygdaloid?

A. A mineral with rounded cavities filled with spar or other mineral. When the cavities are not filled they are said to be *vesicular*. *Amygdaloid* is from the Greek, signifying almond-like.

Q. What is the difference between granite and gneiss?

A. Gneiss is slightly stratified, and will split more easily than granite. One-sixth of granite and gneiss is mica.

Q. What is the difference between a *petrifaction* and other fossils?

A. Most fossils have some of the original matter left—a true petrifaction has not.

Q. Of what is *basalt* composed?

A. It is sometimes composed of augite, olivine, hornblende and iron. Greenstone is called the trap-rock of North America and it resembles the basalt of Europe. Trap is derived from the Swedish, and means a stair.

Q. What is wacke?

A. A soft variety of trap and associated with it.

SIMPLE ELEMENTS.

Q. What eight simple elements can exist in a gaseous state?

A. Oxygen, hydrogen, nitrogen, carbon, sulphur, phosphorus, chlorine and fluorine.

Q. What eight simple earthy and metallic substances unite with these gases, to form the principal rocks of the earth's crust?

A. Silicium, aluminum, sodium, potassium, calcium, magnesia, iron and manganese.

Q. How many simple elementary substances have you mentioned?

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A. Sixteen.

Q. Have you mentioned all the simple elements that have been discovered?

A. No, the precious metals and others of small value, added to the *sixteen*, make *fifty-four*.

Q Which two of the gases chemically united form water?

A. Oxygen and hydrogen.

Q. How much oxygen and how much hydrogen?

A. One-third part by measure of oxygen and two-thirds hydrogen.

Q What two simple gases when mixed form the most of the atmosphere?

A. Oxygen and nitrogen.

Q. How much oxygen and how much nitrogen?

A. One-fifth oxygen and four-fifths nitrogen, including a small quantity of carbonic-acid gas.

Q. What is nitrogen?

A. It is only known to us in the form of gas, yet it will combine with many other substances. It is not known to enter into any of the great mineral masses, yet it is absorbed from the atmosphere by fine earth under buildings and peculiar conditions of the earth's surface.

Q. What is oxygen?

A. Oxygen is a gas void of color, taste or smell. It exists in air, earth and water in great abundance, and in all animals and plants. It forms one-half of the earth's crust and supports animal and vegetable life. It supports combustion and is present in all acid fruits.

Q. What is hydrogen?

A. Hydrogen is also a gas and is not known to occur in nature in a pure and simple state. It is not as abundant in minerals as carbon and oxygen. It exists in the coal formation, and is *fourteen* times lighter than common air. Plants and animals will die in this gas, and a lighted candle will be extinguished

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Q. What is said of sulphur, phosphorus, fluorine, chlorine, iron and manganese?

A. They are generally diffused in most of the rocks. Phosphorus abounds in organic remains. Chlorine in rock salt and in the sea.

The following is a list of all the simple elements yet discovered. Oxygen, hydrogen, nitrogen, sulphur, selenium, phosphorus, chlorine, bromine, iodine, fluorine, carbon, potassium, sodium, lithium, barium, strontium, calcium, magnesium, aluminum, glucinium, yttrium, zirconium, thorium, cerium, lanthanium, manganese, iron, cobalt, nickel, zinc, cadmium, lead, tin, bismuth, copper, uranium, mercury, silver, palladium, iridium, platinum, gold, osmium, titanium, tantalum, tungsten, molybdenum, vanadium, chromium, antimony, tellurium, arsenic, boron and silicon.

Q. Describe veins, dykes, fissures, joints, beds, seams and cleavage in rocks.

A. *Cleavage* planes are found in the slates, and are the result of a crystalline arrangement of the particles in the rocks and are remarkable for their even parallelism. *Joints* divide a mass of rock into determinate shapes. *Fissures* are irregular cracks or openings in rocks, and often filled with calcareous spar or other mineral. *Dykes* differ from veins in being wider, more straight, and in rarely being branching. They are generally filled with granite or trap rock, and are often several yards wide and many miles long. *Veins* are either contemporaneous or injected, the latter being of more recent origin than the former. *Veins* are often metallic, as gold veins in quartz. *Marble* is veined with the same or other earthy material. A *bed* is a layer whose shape may be wedged or shaped otherwise between layers of other rock. A *seam* is a thin layer of another kind of rock, as a seam of coal, of limestone.

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Natural Position of the Different Formations.

Alluvial.	*Highest.*	Surface soil.
Diluvial.	TERTIARY.	Drift.
Green sand.		Chalk.
Oölite.	SECONDARY.	Wealden.
New red sandstone.	*Middle.*	Lias.
Millstone grit.		Coal.
Old red sandstone.		Mountain limestone.
Graywacke.	*Transition.*	Lowest fossiliferous.
Sand and conglomerate.		Metamorphic rock.
Quartz rock.		Clay slate.
Talcose slate, (Schist.)	PRIMARY.	Hornblende slate, (Schist.)
Serpentine.		Primary limestone.
Mica slate.		Mica schist.
Granite.	*Lowest.*	Gneiss.

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STRATIFIED ROCKS.

Q. Into what two great classes do geologists divide the rocks?

A. Stratified and unstratified.

Q. Which are the stratified rocks?

A. All the varieties of gneiss, mica slate, hornblende slate, talcose slate, argillaceous slate, graywacke, limestone, quartz-rock, red sandstone, tertiary formation, diluvium, and alluvium.

UNSTRATIFIED ROCKS.

Q. Which are the unstratified rocks?

A. All the varieties of greenstone, granite, syenite and porphyry.

Q. Which of the classes form the largest proportion of the surface of every country?

A. The stratified rocks.

PRIMARY ROCKS.

Q. How are the primary rocks distinguished from the secondary?

A. By the absence of organic remains and by their crystalline structure and by being more highly inclined.

Q. Which of the primary stratum is supposed to be lowest?

A. The granite having the stratified gneiss next above.

Q. Will you define *stratum?*

A. Stratum (strata) includes a mass of rock and its parallel divisions are called beds and layers. Thin layers are lamina and may be fine, coarse, oblique, or waved.

Q. Describe some of the primary slates, etc.

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A. *Hornblende slate* is associated with gneiss, mica-slate and talcose-slate in all the primary series and its varieties contain quartz, mica, felspar and pure hornblende.

Talcose slate is sometimes pure talc but is generally mixed with quartz, felspar, limestone, mica, and hornblende. It is found associated with mica-slate, argillaceous slate and graywacke.

Chlorite slate is an important variety of talcose slate, compact and of a green color.

Steatite is a variety of talc called *soapstone* and used for furnaces. It is sometimes granular and found in connection with the slates.

Q. Will you describe serpentine?

A. This mineral is classed with the primary rocks and is found associated with talcose slate. It usually contains about 40 per cent. of magnesia and 12 per cent. of water. It is called *precious serpentine* when sufficiently pure to admit of a polish. Very pure specimens are found mingled with magnesia in Hoboken, New Jersey. With lime it forms the beautiful verd-antique marble.

Q. Will you describe augite?

A. Some writers consider augite as only a variety of hornblende, as it is proved that by bringing hornblende into a state of fusion it will sometimes take the form of augite when cooling. Augite and felspar form the greatest portion of all unstratified rocks. Fingal's cave is greenstone and basalt. The island of Staffa is basalt and the columns rise 70 feet. The Giant's causeway is basalt and the columns rise 200 feet. The palisades on the Hudson are greenstone. On the Columbia river basaltic columns rise 1000 feet, forming crystalline structures on the grandest scale.

Q. Will you describe lava?

A. The melted matter that is or has been ejected from a volcano, is called lava. It is composed mostly of augite and

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felspar. When augite predominates it is called Basaltic Lava; when felspar predominates it is called Trachytic Lava. Many different kinds of minerals are found in lava, but in small quantities.

Scoriæ is basaltic lava cooled in the open air, and is vesicular.

Vitreous Lava has the appearance of glass.

Pitchstone is less glassy and is usually composed of felspar and augite but often of some other material.

Pumice is vesicular trachytic lava. When lava contains angular fragments it is called volcanic breccia. *Volcanic Tuff* is formed when the lava becomes mixed with sand, gravel, shells, etc., and cemented together by lime or otherwise.

Other substances such as fragments of granite and other kinds of rocks are thrown from volcanoes and every sort of mud and ashes and also pure sulphur and its gases and many other substances—such as gypsum, magnesia, sulphate of iron, salt, potash, copper, cobalt, etc. Hence we may infer that the burning mass, deep within the earth is of the same composition as the other rocks. The interior crust of the earth must abound with ragged projections, which, when loosened, would produce the phenomena of an eruption of a volcano. If we put a colder substance into a melted mass of great heat the intruding matter is either ejected or the substance overflows. As felspar and augite predominate in the unstratified rocks, so do they also in the lavas. Hence we find the older and the most recent formations nearest allied. Gases and the water that finds its way through the earth's crust from the ocean and inland seas and other fountains of water, must have had great power in causing islands to rise and sink, and other strange phenomena.

Q. Describe volcanoes.

A. There are now over three hundred active volcanoes of

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which one hundred and ninety-three are upon the islands of the sea—several are quite inland as in Mexico and Central Asia.

Solfatara is a volcano which only sends forth vapor, steam and gases from its crater. When mud is thrown from a crater it forms a substance called *Trass.* The basaltic tuffs are called *peperino.* The expansive power of steam and gases under the earth's crust is supposed to cause earthquakes, and they occur about as often as volcanic eruptions. If the earth is still cooling, its contraction would cause earthquakes.

TRANSITION ROCKS.

Q. Describe transition rocks.

A. These rocks lie between the primary and the secondary and are sometimes called the *silurian*, *cambrian*, or *graywacke system.* The lowest of these rocks is *clay slate* in which no organic remains have yet been found. In the limestone that interstratifies the upper members of the series, zoöphytes and mollusca are found, but no plants.

A writer says: this extensive deposit of transition rock of vast thickness in Wales embraces the lower part of the graywacke group and the clay slate of other geologists. The whole is argillaceous, but varies from the finest clay slate to the conglomerates, containing fragments of quartz, felspar, mica and jasper, the cement being argillaceous.

The silurian rock embraces the upper graywacke, the graywacke slate, or shale. Their composition is argillaceous, calcareous and arenaceous, and often conglomerate and interstratified. The materials sometimes produce the most delicate slate of a dull appearance. These rocks contain organic remains, and the limestone is sometimes crystalline. This vast formation extends over Norway, Sweden, and in Russia

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eastward to the Uralian Mountains, and it is supposed that the Mississippi Valley is underlaid by these rocks.

Some writers on Geology place the old red sandstone as belonging to the graywacke group, as it is often found in connection with them and next above. Many include all the transition with secondary rocks.

SECONDARY ROCKS.

Q. Describe old red sandstone, mountain limestone, coal measures, new red sandstone, lias, oölite, cretaceous or chalk group.

A. The old red sandstone is lowest of the series, and is usually of a red color, conglomerate or schistose. The mountain limestone next, and the coal measures, interstratified with sandstone and shale uppermost. The coal measures are most abundant in the United States. One basin in Pennsylvania is sixty miles long, two miles wide, and one hundred feet deep. The anthracite of Europe, is found principally in the graywacke, and some suppose the graywacke to have been once coal, having lost its bituminous qualities. Coal is found in mica slate, in New England. In Scotland it is found in the lias limestone. In Germany it is found in clay of the tertiary strata.

The new red sandstone lies next above the coal measures. The lias or argillaceous limestone next. The oölite next. The wealden clay, sand and chalk last. The oölite consists of interstratified layers of clay, magnesian limestone of yellow and various colors, variegated marls and clays, and is divided into three distinct groups; upper, middle and lower. The oölite is sometimes called roestone, having small globules imbedded, resembling the roe of fishes. The oölite group contains a great number and variety of organic remains.

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The cretaceous or chalk group consists principally of sand and sandstone in the lower parts, and in England chalk in the upper; but in the United States the chalk is wanting, its place being supplied by ferruginous sand formation.

Chalk is composed of pulverized carbonate of lime. Flint is found in the upper portion of the beds, often in parallel position. The green sand of this formation is composed of a number of ingredients, silica, alumina, water, potassa, lime, magnesia, manganese, and oxide of iron, and is used as a fertilizing manure. The wealden formation of this series is named from the wealds or woods of Sussex and Kent in England, and is composed of conglomerate, sandstone and limestone and clay, and is remarkable for the remains of fresh water and terrestrial animals. Similar beds are found on the continent and other places.

Q. What is a formation in geology?

A. A formation consists of such rocks as are supposed to have originated under similar circumstances in the same geological period.

TERTIARY FORMATION.

Q. Describe the tertiary strata.

A. The tertiary rocks are divided into four layers or groups of marine strata, separated from each other by strata containing terrestrial and fresh water animals The marine strata contains remains peculiar to the ocean. Some geologists give the names of Eocene, Miocene, and old and new Pliocene to the different strata. The tertiary rocks are distinctly stratified and are supposed to be deposited by water and cemented by chemical agency as beds of gypsum, limestone and rock salt. The strata are usually horizontal or slightly inclined. Among the varieties of tertiary rocks are plastic clay, limestone, gypsum, green sand, marl, lignite, salt,

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buhr-stone, tufa, calcareous and silicious sand. Some varieties are concretionary and silicious. The tertiary formation covers more than half of Europe, and is abundant in the Southern and Middle States. It is next below drift and contains many peculiar organic remains, and the beds of clay, sand, marl and gravel are more or less consolidated.

Lignite or brown coal is found in the tertiary stratas and is supposed to have originated from peat. Jet is a variety of pure lignite.

DRIFT OR DILUVIUM.

Q. Describe drift.

A. Drift is composed of sand, gravel, loose stones, pebbles and bowlders. When the bowlders are of great size they are called erratic blocks and lost rocks. Sometimes they are poised upon other rocks and are called rocking stones. The lowest of these strata are coarse materials, the next clay, then sand.

Q. What precious stones are found in drift—what metals?

A. Many of the precious stones and metals are found in drift. The diamond, the sapphire, the topaz, the ruby and the zircon; also, platinum, gold and tin. Plumbago is supposed to be formed from anthracite coal, having undergone a change. In the Alps it is found in clay slate.

Q. Define strike and dip.

A. Strike and dip are terms used by geologists, and are defined by Prof. Hitchcock, as follows: "The angle which the surface of the stratum makes with the plane of the horizon is called its inclination or dip; and the direction of its upturned edge is called its strike or bearing." The exposure of a stratum at the surface is called, in the language of miners, outcrop.

Q. Describe moraines.

A. *Moraines* consist of sand with pebbles, and oftener bowlders, sand and pebbles. These accumulations are very

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common in New England. In Berkshire County, Massachusetts, near Monument Mountain, and in New Marlboro', where they are either extended or crowded in conical elevations, some of them have deep cavities, "as if scooped out by the hands of a Titan." Geologists suppose these to have been deposited during the period of drift, either by icebergs or glaciers at the bottom of an ocean.

ALLUVIUM.

The lowest deposits of the alluvial consist of—

1. Sandstones, conglomerates and breccias.
2. Apothemite.
3. Chloride of Sodium, (sea salt.)
4. Hydrate of Magnesia.
5. Hydrate of Iron.
6. Sulphate of Lime, (Gypsum.)
7. Bitumen.
8. Silicious Marl.
9. Silicious Sinter.
10. Coral Reefs.
11. Calcareous Tufa, or Travertin.
12. Marl, Peat, Sand and Soil.

Q. Describe sandstone, pudding-stone, breccia, bog-ore, silicious marl, and silicious sinter.

A. Sandstone is cemented sand. When rounded pebbles are cemented it is called plum pudding-stone, or conglomerate. When the fragments are angular, it is called breccia. Hydrate of manganese is called wad when found in low grounds. Hydrate of iron or bog-ore is deposited from water, that holds it in solution and it is a wonderful discovery that it is made of the shields of infusoria. The vegetable remains in bog-ore are generally perfect petrifactions. Silicious marl

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is composed of the fossil silicious shields and skeletons of microscopic animals, called infusoria, or animalcula, that have lived and died where this substance was deposited.

Silicious sinter or tufa is composed of silica, formed from the deposit of the water of Thermal Springs. Breccia is sometimes formed of broken pieces of this sinter mixed with clay.

Q. Describe coral reefs—how built?

A. Coral reefs are composed of the carbonate of lime, and are formed by myriads of small animals called polyps. The polyps build the reefs in a circle, and continue their immense structure until it reaches the edge or top of the water. Near the islands of Bermuda they extend several miles under water, so that it is impossible to enter port in a storm. Some of these coral islands in the Pacific ocean extend over a thousand miles in length and four hundred in breadth, and are found everywhere abundant in the Southern seas, so that navigation is often obstructed.

Q. Describe bitumen.

A. Springs containing this substance are found in Asia, Europe and in the United States. In the island of Trinidad, in the West Indies, is a pitch lake three miles in circumference. It becomes hard on the surface some seasons of the year, at other times it is soft.

Q. Describe petroleum or rock oil.

A. Petroleum and asphaltum seem to be of the same substance. By boring through the strata overlying it, the oily substance arises to the surface on the principal of hydrostatic pressure.* If the strata below is impervious the liquid substance would be securely deposited for ages.

Q. Describe artesian wells.

* Or, in other words, if the strata be curved upward, much of the reservoir may lie above the oil reached, and even above the point of the commencement of excavation, in which case it must overflow.

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A. Artesian wells are named from being found at Artois, the ancient Artesium. Formerly the borings were performed by a continuous iron rod with a drill at the lower end, but recently the Chinese method has been adopted, consisting of a cylinder of iron, and a rope attached. The materials are brought up by means of borers with valves connected to the lower end. Wells for water have been sunk in France over 1000 feet, and in the United States, 900 feet.

Q. Describe tufa, stalactite, and stalagmite.

A. Calcareous tufa, or travertin is deposited from thermal water and is composed mostly of lime. It is produced in abundance from Thermal Springs of ordinary temperature, as at Saratoga, N. Y. Sometimes it is precipitated from the water of rivers. Concretionary calcareous deposits formed in caverns are similar to tufa or travertin. Those depending from the roof above are called stalactite, and those from the floor are stalagmite.

Q. Describe marl.

A. Marl is of several kinds. Calcareous, silicious, aluminous, and green sand marl. The latter is found sometimes below peat, and is of much value as a manure. It is said that by plunging a rough stick below the peat the sand will adhere to it though covered with mud. The genuine marl may be detected by applying an acid. If it effervesces it is genuine marl.

Alluvial, or shell marl, consists of lime, clay and geine. It is usually a fine powder found beneath peat, or at the bottom of ponds. It contains the deposits of lime from water, and small fresh water shells.

Q. Describe peat—That of New England—What will dissolve the fibre of peat—What is geine—Peat bogs, etc.?

A. Peat seems to be the product of cool and temperate climates, as the vegetable matter of which it is composed would decay too rapidly in warm countries to form peat. It

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is composed of undecomposed vegetable matter mixed with a substance called geine. The best peat is destitute of fibres and forms, when dry, a fine black powder. The deposits of peat are often forty feet thick. Wood ashes or lye will dissolve the vegetable fibre of peat for agricultural purposes. There is peat enough in New England to make her barren wastes as fruitful as a garden. Geine is composed of sixteen atoms of oxygen, two atoms of hydrogen, and sixteen atoms of carbon; and it is this substance that forms the richness of the western prairies, forming abundant carbonic acid for the nourishment and growth of vegetation. It is the opinion of distinguished chemists that vegetables are nourished solely by carbonic acid, and that geine acts no other part but to supply that acid. Peat Bogs are increased by the decay of a kind of moss of the genus sphagnum whose roots decay while the top grows with new life. On the Shannon in Ireland, is a bog fifty miles long, and one-tenth of the whole surface of the island is covered with peat. The interior and eastern part of Massachusetts abounds in peat. The increase of peat is sometimes seven feet in thirty years. Lignite and bituminous coal are supposed to have been formed of peat. Trees have been found standing in peat bogs, and animals have been preserved in them for a long time.

Q. Describe downs or dunes.

A. Downs or dunes are vast accumulations of sand. They are composed of silica, and destitute of animal matter, and cannot sustain vegetation unless animal or vegetable matter be supplied.

Q. Will you define soil?

A. Soil is defined by Professor Hitchcock to be "disintegrated and decomposed rock, with such a mixture of vegetable and animal matter that plants will grow in it." He says also that it is composed generally of silica, alumina, lime, magnesia and iron in about the same proportion that they are

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found in the rocks. Silica is the most abundant ingredient. The presence of animal matter is proved by burning it off. It is estimated that lime forms one-seventh of the crust of the globe, and that silica forms nearly one-half; alumina one-tenth; magnesia forms but a small part, but is widely diffused. Water and congelation act very powerfully upon rocks and soil; mechanically in getting between the particles, and chemically in dissolving the substances that they contain, so that the rocks are wearing away, and not increasing as some unlearned persons suppose. It is true, however, that in some few localities the alluvial does form into rock. Particles of iron are forming ores in some places. As the solid strata wears away the fragments are carried by water to lower parts and deposited in the form of sand, gravel, clay and loam, but all such deposits, consolidated or not, are denominated alluvium.

WATER.

We see the overflowing benevolence of the Creator in all His works, but in nothing more perhaps, than in the distribution of water and in the mode of rendering it subservient to the condition of living beings. The ocean is preserved by salt and by being constantly in motion from the heated to the frozen seas. How beautiful and refreshing are the springs and fountains of the dry land, and the laughing streamlets of the rocky glens.

Q. Describe subterranean streams of water.

A. The arenaceous rocks allow the water to percolate through them, but some of the argillaceous strata are almost impervious to it, so that a perfect reservoir is formed above the latter strata. When borings fail it is not always because no water stratum is reached, but because the water stratum is not high enough above the surface of the place of boring. When

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such subterranean streams of water lie so horizontally they can only be brought to the surface by forcing pumps.

Thermal Springs contain silicia and deposit it. Other waters do not hold it in solution. The hot springs of Iceland have deposited silicious matter a mile in diameter, and many feet thick. Thermal waters are not confined to volcanic regions but are supposed to be heated by the same agency of internal heat. Hot springs are found on the Alps, Pyrenees, Caucasus and the Ozark Mountains. In Germany thermal waters have been reached by artesian wells and used to prevent the frost from stopping machinery. The silex deposited is called silicious sinter. Other mineral substances besides silica are also contained in the waters. All waters filtering through the rocks contain, more or less, mineral matter.

Many springs emit gases. Chalybeate springs contain iron; cupriferous springs, copper; saline, salt; calcareous, lime. Every known mineral may be carried by water and deposited. Mineral springs exert a twofold influence upon rocks, first by dissolving them, secondly by depositing the mineral matter in its course, and upon the bottom of seas, lakes and oceans, and by the difference in the character of the deposits the student can see why the rocks differ in the same geological period. Chalk may have been depositing in England while sand and clay beds were forming in New England. Hitchcock says, "the ferruginous sand of this country corresponds with the chalk formation of Europe."

Springs are *perennial* when deep seated, intermittent or shallow, when they flow from sand or gravel. Springs act mechanically when they cut out channels for themselves, and

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QUESTIONS.—Describe thermal or hot springs. Describe other springs. How do springs affect rocks? Do the deposits form different rocks? What does Prof. Hitchcock say of the ferruginous sand of this country? When are springs perennial? How do they act mechanically and chemically?

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chemically when they dissolve portions of the rock through which they pass. Rain water generally contains carbonic acid and ammonia and other ingredients. The rain that falls in a year is varied, but generally ranges from twenty or thirty inches to several feet. In tropical regions rain is periodical and falls for several weeks at certain seasons, giving rise to inundations, and the melting of snow and ice from mountainous regions render the floods destructive in their course and carry away soft earth and often trees, rocks and such animals as may be entombed in the debris. In the early ages when gigantic plants grew in northern latitudes, streams must have been much larger, carrying silt and debris on a much larger scale, forming plains and deltas, modifying the surface of the earth and preparing it for future habitation.

The water from snow and rain sinks into the earth and passes out through rents and fissures to the surface where it forms springs, lakes and rivers.

Tides rise and ebb from four to forty feet enter into rivers many miles mingling the fresh water with marine deposits. As at the present time, so in ages past, and the student can readily perceive why marine and fresh water fossils are mingled in the sedimentary strata. *Waves* also affect the surface of the earth's crust by tearing down soft cliffs year after year and forming land in other places. Rivers form land very rapidly in some places. In draining the surplus waters from the earth, they often form the shape of the Greek letter Δ at their mouths. The mouth of the Po has gained eighteen miles in two thousand years; the Nile, two hundred and fifty; the Niger one hundred and seventy. The deposits from the waters of the Rhone form on the shores

QUESTIONS.—What does rain water contain? How much rain falls annually? What effects do inundations produce? What in early ages? How are springs formed? How do tides affect sedimentary rock? How do waves affect the earth's crust? Rivers?

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of the Mediterranean solid crystalline rock. The mud of the Ganges discolors the waters of the Bay of Bengal the distance of sixty miles; and that of the Amazon, three hundred miles. The land formed by the sediment of the Niger is estimated at twenty-five thousand square miles, and the amount of silt brought down annually by the Ganges is sixty times heavier than the largest pyramid. By these deposits the geologist sees clearly how the secondary series of conglomerates, sandstones and shales were formed.

Currents in the ocean represent rivers on the land by a continuous movement carrying bodies to a great distance. Rivers not only cut through solid rock, but fill up their own beds with sediment, as the Mississippi. The bent strata is the natural channel for rivers, yet when obstructed they force their own way. The Nerbuddah, in India, has scooped out a channel in basaltic rock one hundred feet deep. Conglomerate rock in the Alps has been scooped out at the depth of seven hundred feet. The channel in Niagara River is one hundred and fifty feet deep the distance of seven miles. The cataract has receded fifty yards during forty years.

The water that comes from the mud and stream of volcanoes, may be produced in two different ways. Water may find its way to a heat sufficient to convert it into vapor, and it may be formed by the union of oxygen and hydrogen in the internal cavities of the deep-seated fires. There are three hundred and three volcanic vents. Two-thirds are upon islands, and the remainder near the sea, with the exception of those in Central Asia and in Mexico. Only a few volcanoes

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QUESTIONS.—Do some rivers deposit lime and others clay? What rivers have large deltas at their mouths? Are ocean currents like rivers? Where the current is not swift, do rivers deposit debris in their own beds? Are the bent strata of valleys the natural channels of rivers? Do they sometimes cut away rocks? Has Niagara worn the rocks? Can water be formed in volcanoes?

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are constantly active, the eruptions on an average being only about twenty a year. The volume of water ejected has not been estimated. A few volcanoes are never quiet. Stromboli, one of the Lipari islands, Villarica in Chili, Popocatapetl, in Mexico, and one in Lake Nicaragua, are constantly burning.

The history of Jorullo in Mexico is very interesting. On a plain one hundred and forty miles from Guanaxuato, flames were seen bursting from the ground, and fragments of burning rock were thrown to a great hight, until a mountain was raised sixteen thousand feet above the plain, surrounded by six volcanic cones of less hight. In 1819 an eruption occurred, and the ashes fell many inches deep, one hundred and fifty miles distant. Humbolt visited the plain of Malpais on which Jorullo stands, twenty years after the first eruption of 1759. Previous to the eruption, hollow sounds were heard under ground, and slight earthquakes occurred. The whole region is volcanic.

A volcano on Hawaii, one of the Sandwich Islands, is worthy of description. It is situated upon an elevated plain, ten thousand feet above the level of the sea, at the base of a more elevated part. Two steep terraces surround the crater, from one hundred to two hundred feet high. The outer one twenty and the inner one fifteen miles in circumference. The inner rim is ten miles, and the vast molten lake is a yawning gulf, six miles in circumference, and one thousand five hundred feet deep. In 1840 an eruption took place. The lava, after partially filling up the crater, found a subterranean passage eight miles under ground, and flowed on the surface to the sea, a distance of thirty-two miles. A kind of volcanic glass, called by the natives Pele's hair, is formed by the wind, as it catches the molten waves, and spins them into

QUESTIONS.—How many volcanoes are active? Mention some that are never quiet. Tell the history of Jorullo in Mexico. How large is a volcanic crater on the Sandwich Islands?

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threads which are found hanging upon the sides of the crater. Before the introduction of Christianity, Pele was regarded by the natives as the divinity of the volcanic mountain. Lava, when cooled, is a non-conductor of heat, so that a stratum of ice may remain for years under new ejected lava and ashes, which in turn are covered with snow and ice, the mountain forming, as it pierces the clouds, a continual reservoir of melting snow and condensing vapor.

PALÆONTOLOGY.

[Proper questions will be suggested to the instructor who reads over the following pages.]

Palæontology is a description of organic remains. They are of two kinds, *fossils* that retain some of the original, and *petrifactions* which do not, and are divided into three classes:—MARINE, FRESH-WATER and TERRESTRIAL. The first, or oldest, are found in the graywacke, and consist almost entirely of *marine shells* and *zoöphytes*. The fossil *zoöphytes* are an extensive class of marine animals, and distinguished by their simple and radiated structure differing from the present existing species. They are found as high as tertiary strata. In this marine class are found the *encrinite*, of which thirty different species have been taken from the coal formation. The encrinite had a cup-like body, and was fixed to other substances, and only moved as far as it could bend its flexible body, which consisted of little bones forming a column. On the top or margin of the cup were five articulated arms, divided into many fingers, surrounding the mouth. The number of bones composing the head was twenty-six thousand, and the whole apparatus of muscles three hundred thousand,—a number greater than any other animal. (Man has two

QUESTIONS.—What of Pele's hair? Is lava when cool a conductor of caloric?

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hundred and thirty-two muscles and two-hundred and forty-one bones.)

Polyparia (polypina) are the small radiated animals that build the coral reefs. They are attached to their stony habitations in various forms of radiation. The body is not flexible like the encrinite, but they obtain their food by small hairs on their margin, which they move rapidly, forming currents of water which bring food to their mouths. Their structures rise symmetrically, as if influenced by one instinct of a compound animal. They are multiplied by divisions and buds called gemmules, which, falling away, form distinct animals. (It is a singular fact that the fossil remains in the colder climates are most like those now found living under the tropics.)

The greatest part of organic remains are of marine origin; even the fresh water and terrestrial relics have mostly been deposited beneath the ocean. The thickness of the fossiliferous strata in Great Britain, has been ascertained to be six miles, and that two-thirds of earth's rocky crust is fossiliferous. The Alps and Pyrenees abound in animal remains, eight thousand feet, and the Andes, fourteen thousand feet above the level of the sea. The microscopic animalcula are very abundant. One grain in weight of rock, produces one thousand of one species only.

Non-Fossiliferous Stratified Rocks.	*Fossiliferous Stratified Rocks.*
Gneiss.	Diluvium.
Mica slate.	Tertiary strata.
Chlorite clay.	Cretaceous group.
Quartz rock.	Wealden rocks.
Hornblende.	Oolitic group.
Mica.	New red sandstone group.
	Coal measures.
	Carboniferous limestone.
	Old red sandstone.
	Graywacke, (cambrian and silurian.)

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Infusoria can only be seen with a powerful glass. A Prussian naturalist has described seven hundred and twenty-two living species, which swarm everywhere, even in the blood of healthy animals. These animalcula have their softer parts protected by a shield or skeleton which is not changed by the strongest heat, so that they remain entire in the rocks, and their organic structure can be seen by microscopic views. The remains of fossil shields of *infusoria* forms the scum upon springs of water, and in the marl found beneath peat.

Articulated animals.—These belong to the second class of fossils, and are not numerous. They are distinguished by having their envelopes connected by rings. Insects, spiders, scorpions, crabs, lobsters and angleworms are of this class; also the *tribolite*, which does not appear above the carboniferous strata. The tribolite had numerous eyes, which are perfectly preserved in graywacke rock.

The description of fossil shells (being of rocky material,) belongs to geology. The science of *conchology* embraces the *molluscous* division of the third class of fossils, and includes such animals as are destitute of spinal marrow or articulated skeletons, but whose muscles are attached to a calcareous covering called a shell, or to a soft skin externally, and to a hard body within, analogous to a shell. They are the most abundantly diffused among living animals, and the great number of their remains in the rocks prove either that they were more abundant in the rocks of ancient time, or that they were more easily preserved. The *nautilus* belongs to this class, and with the exception of one or two species, the nautilus and other chambered shells have disappeared from the earth. The *ammonite* was a species of nautilus, and some have been found four feet in diameter. The *cuttle-fish* (loligo sepia) has a bag within its body, from which the sepia used in painting is obtained. It has also an internal bone, or in

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some species a thin cartilaginous substance resembling a quill. A lady in England has discovered both the ink and quill in a fossil state, in lias limestone, and the ink in the fossil state made the best of sepia paint.

The *spirifer* and *producta* were bivalve shells and are found as high as the new red sandstone above the carboniferous rocks. The *terebratula* is a bivalve and found in the graywacke and in all fossiliferous rocks, and among living mollusca.

Vertebral animals are divided into *four tribes: fishes, reptiles, birds* and *mammalia*—the noblest division and last of created beings.

The science of Ichthyology embraces the fish tribe. Fossil fishes are found in all the fossiliferous rocks from the graywacke upwards. Agassiz divides fishes into four orders, according to the character of their scales. The fossil fishes change abruptly in all the great geological formations, each new formation having a new creation of some of its living tribes of fishes; and of its seventeen thousand different species, none are found in our present waters.

Reptiles, the second division of vertebral animals, were in ancient times remarkable for their enormous size. Dr. Buckland divides the fossil *saurians* into terrestrial, marine, flying, and amphibious; "fit companions for the kindred reptiles that swarmed in the seas and crawled on the shores of a turbulent planet." Tortoises and crocodiles have been found fossil in all formations above the coal formation.

Ornithology is a science that describes the *birds*—the third division of *vertebral* animals. Many species have been found fossil in diluvium, tertiary and wealden formation. Impressions supposed to be the tracks of birds are found in the red sandstone of the Connecticut river.

Mammalia, the fourth and last division of vertebral animals, includes man at the head. The fossil mammalia are

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found mostly in the tertiary strata and drift. They are principally of existing species. Many remains are found in caverns. Some caverns have been used as sepulchres, and the bones of man are mingled with those of animals, pottery, and relics of a rude people. In the northern parts of Europe, Asia, and America, an extinct species of the elephant, called mammoth, is found in a fossil state. One was found encased in frozen mud and ice on the northern shore of Siberia, with hair and softer parts preserved. Its hair consisted of black bristles fifteen inches long, with wool of a reddish brown color. It is now in the museum of Natural History in St. Petersburg. Its length is sixteen feet, hight nine feet. The bones of one hundred mastodons and twenty elephants have been dug from the Big Bone Lick of Kentucky. Animals approaching nearest to the structure of man have been found in a fossil state, in drift, in India, and in tertiary strata in France. The fossils were a gigantic species of monkey. Bodies of men* have been found in rock of recent formation. Tracks of enormous birds and animals are found in many places in the United States and in England. In the red sandstone of the Connecticut, impressions of raindrops or hail are seen, so beautifully impressed that the beholder may discern the direction of the wind.

> The science of geology— how beautiful to tell,
> And mark the records of the past on fossil plant and shell.
> Our thoughts go back in sympathy with all that living train,
> But nothing links them to our hearts, like impress of the rain.

Plants.—Six hundred fossil plants have been found in the rocks, of which the *algæ* or *sea weeds* are the lowest. About the same number of submarine plants are found in the ocean at the present time. *Mosses* or *musci* are but rarely preserved in the rocks, on account of their delicate structure.

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*One may be seen in the British Museum.

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Ferns or *filices* are very abundant, and were equal in size to those now growing in the warmest climes, which rise to fifty feet. Two hundred species have been found in the coal formation of Europe; only about forty living species grow there now. A very interesting fossil plant is found belonging to the *club moss* tribe, called *lepidodendron*, which fills the chasm between flowerless and flowering plants better than any existing species. It is found in the coal formation, forty feet in length. Thirty-four species are described, and the whole genus is extinct.

Many beautiful and interesting fossil plants occur—among which is the *cycadeæ* family, a link between the palms, ferns and pines. They were very abundant in the time of the coal formation, and some species now exist under the tropics.

How strangely imposing must the world have appeared during this period with such gigantic and luxuriant vegetation. Surely the Omnipotent Creator was laying up a bountiful store for the *living* ages that were coming. Some suppose that as few animals were living then that the atmosphere was more highly charged with carbon, which caused the plants to grow large, also that warmth and moisture were greater at that time.

Some of the foot-marks of tortoises and crocodiles are supposed to have been formed upon the bottom of an ocean, before the continents were raised above the water. That the continents have been covered by the sea is very conclusive, as the tops of the highest mountains bear evidence of having been submerged. Pieces of coral reef and shells are found on the Catskill Mountains. Large shells of unknown species are found in boring for artesian wells, in Alabama and Mississippi.

Many wonders occur everywhere. Eight species of birds have been found in a bed of gypsum near Paris in France. Flies and other insects are found perfect in amber. Forests of standing trees imbedded in stone are found in many places;

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one under an ancient city in Italy. Beneath these forests are beds of shells, and beneath these shells again vegetable remains abound, showing that the land has been successively submerged. Ancient Rome was founded upon a marine formation covered with volcanic products. Submarine volcanoes often form islands in the sea, which sometimes are again submerged. A volcano in the Indian Sea shook the earth thousands of miles, and filled the air with ashes two hundred miles. Cotopaxi once ejected a piece of rock of one hundred and nine cubic yards the distance of nine miles. This shows the greatness of the power that could raise islands and continents.

The atmosphere to the reflective mind is one of the greatest wonders of earth's creations. Portions from highest accessible elevations have been analyzed, and found to be the same as that in the valleys. There is something strangely beautiful in the union of the elastic elements walking hand in hand everywhere, supplying the infant's breath, lingering with the dying, murmuring in the soft winds, whispering in the breeze, and howling in the tempests; yet it is the same purifying element, although over earth's surface millions of fires are consuming oxygen, animals are exhaling carbon, and volcanoes are pouring forth all sorts of impure gases. Surely the atmosphere was formed by a beneficent hand.

But whence comes the saltness of the seas? Geologists do not tell us; so we will hazard the opinion to say, that its soda came from the felspar that was washed from the wavy gneiss, leaving the refuse to form into mica-slate as the condensing vapors began to cool upon the molten nucleus; and that *Pluto* assisted *Neptune* to press, bend, contort and fold the mica-slate. No one can observe the mingling of the different strata of granite, gneiss, and mica-slate, without being reminded of fire, and by examining gneiss and mica-slate we find that the aggregate portions of which they are composed have been worn by the attrition of water. They speak a lan-

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guage not to be mistaken; and the sedimentary rocks above, with their alternations of rock and imbedded fossils, give us a correct history of planet Earth since that early period.

It is believed that the interior of the earth's crust consists of immense cavities as uneven as the outer globe, and that the nucleus is not yet cooled, and that the earth is enlarging outwardly from the volcanic materials such as gases, water, ashes, and lava that are borne by the waters and the winds over earth's surface.

We may safely rely upon the changes that are taking place in nature at the present time, to explain what has taken place in past time. The history of the world as written in the rocks, speaks of glaciers, icebergs, tempests, storms, floods, tides, earthquakes and volcanoes; as well as existence of calm still waters.

The earth being an oblate spheroid—its diameter shorter from pole to pole—proves that it was once in a fluid or semi-fluid state; and its present active volcanoes also prove that there still is deep-seated, internal fire. The earth, as a whole, is five times heavier than water, and its rocky portions must be very equally balanced to roll over at the rate of about one thousand miles an hour, and speed its way on its yearly path at sixty-eight thousand miles an hour, without disturbing the tides, currents or streams of water. It is thought that the numerous islands that dot the Southern Pacific Ocean are the remains of a submerged continent, and that it might have been caused by the raising of the Andes. At the present time islands rise and sink in the ocean, and it is not strange that larger pieces of land should be subject to the same phenomena when the earth's crust was much thinner than now. By some law of nature, probably the necessity of evaporation, there is more water than land. It is calculated that the greatest depth of the Atlantic Ocean is nine miles, and the mean depth of all water three miles. The highest mountains

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are nearly five miles, and the mean hight of the dry land two miles. So that if the granite and gneiss were placed in their original position, and the mountain eminences leveled, and the caverns of ocean filled, the whole surface of earth would be covered with water. No land to absorb evaporation, vapors would rise, and we would have the dawn of creation again, when darkness covered the deep, and the Spirit of God moved upon the face of the waters. Then—

Man had not lived to see the dripping earth
Come swelling from the sea—with barren cliffs
Scathed by internal fires, and broken up,
And far along the range the lava hot
Flow cooling down the sides, and burying deep
The myriads of living tribes of ancient sea.
Man had not lived to see
The cereal blade—the dark green plant of huge
Gigantic size; the trees and monstrous ferns
Waving in gassy carbon, dense and damp,
Fit only for foul reptiles crawling low
In dark and fetid pools or dismal shade.
Man had not lived when new Earth writhed and shook
In her primeval birth to form the dark
And shining rocks * to bless the nobler tribes.
Hail brighter day! when the acacia's bloom
And orange groves sent forth their sweet perfume
And juicy fruits became the food of man.
Thanks unto Thee O God! that now Thine own
Blest teeming millions love and praise Thy name.

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*Coal formation.

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HOW OLD IS PLANET EARTH?

Go ask the rocks and Bible,
  Search everywhere for light,
And let the search go deeply down
  Into the shades of night;

Down in the depths of caverns
  Where fishes have no eyes,
And in the vault of heaven
  Where planets set and rise;

Down in the depths of ocean
  Where grow the tangled weeds,
The algæ and the coral,
  And plants that have no seeds.

You'll find them in the strata,
  Go, look with reverent view,
For in the lime's old, rocky bed
  They're sprinkled through and through.

By lakes and springs and rivers,
  We read, in lettered lines,
How many years since grew the oaks,
  The cedars and the pines.

By every upheaved mountain,
  In every dark ravine,
Where runs the ancient fountain
  Marking the lines between.

Float on old earth in brightness,
  For every moon shall tell
How true Old Time has marked thy age
  In every rocky cell.

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Then let all praise be given
To Him who rules above,
That of the soft and genial earth,
God fashioned man in love.

That flowers sprang up in beauty,
And the sweet magnolia bloomed
Over where slept the mastodon,
And chieftains were entombed.

That since the same bright era,
He made the palms to wave,
And spread the cereal grasses
O'er Eve and Adam's grave.

Hark! hear the tramp of millions
Upon the green earth spread,
The din of mighty cities
Above the ancient dead.

H. T. W. A.

WHO MADE THE WORLD?

Oh! who hath made this beauteous world,
So splendid to the sight—
And who hath o'er our heads unfurled
Such brilliancy by night!

Famed Chance, thou sceptic's god—didst thou create
The earth? and with thy mighty strength didst thou
So permanently fix this mass of matter,
So vast in its extent, so high, so deep?
Mysterious Chance—didst thou create the hills
And vales, and elevate the mountains high?

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Didst thou spread forth and beautify the plain,—
Form trees so perfect in their symmetry
And animals more perfect still; and herbs,
And shrubs and flowers so sweet, that border on
The stream, and deck the woodlands wild?
Didst thou create the rays of light that shine
So brilliantly upon this lovely earth;
And e'en the sun, and stars innumerable?
Oh! Oh! how much for thee to do! And yet
Create a moral world—the mind profound,
With reasoning powers, and thought, and will!
Too much—I never can believe thou didst.
Ah, no! All things were never made by *chance;*
For lo, the name of God is plainly stamped
Upon Creation. The smallest leaflet
Light trembling in the wind, is but a tongue
To talk of Him. In low and murmuring sounds
The summer breeze, comes whispering to the soul!
The trees, the meadows bright, the streamlet near
And every pebble on the water's edge,
Hath each a silent language infinite.
The waterfall, the tempest and the storm,
Only speak more fully of his greatness:
The seas that send their watery vapor forth
Condensed in clouds and rain, to bless mankind—
Extensive forests, and the boundless ocean—
All, all speak of their Great Original.
Hath any viewed the broad-spread lake, and cast
A look upon the other shore, and kept
Their thoughts on earth? Ah, no! the immortal mind,
Unbounded thought, did not stop on the shore
And linger so unnaturally on earth—
But bounding thence, e'en to the shore of time,
It glanced the region of eternity—
And spirit-like communed with spirit near
Its ever glorious and native home.
Hath any stood on mountain cliffs and thrown
A far and lingering gaze o'er nature's scenes,
Till awe and admiration filled the mind.
And felt not there a consciousness of God?
Hath any stood beneath the ethereal arch

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Of Heaven at evening's hour, when thousand stars
Looked down upon our favored earth, with all
Its wonders deep, and blessings large and full,
And felt not there to bow in reverence to
The God of such immensity—to yield
His heart to him who hath a right to all?
Thou child of this blest sphere turn, turn, and view
Thyself, thine own immortal self—search deep,
And when thy soul is freed from sin and guilt,
Then thou wilt know the truth "There is a God."
Thou'lt hear him speak in all his handiwork—
And know he did create the earth, the heavens,
The star-clad milky way, and all that 's placed
Beyond the narrow reach of finite minds,
And though I cannot fathom all his works,
And all things know; yet I'll believe there is
A Great First Cause, and I will henceforth learn
To gaze with new delight, on Nature's works—
And praise with holy reverence Nature's God.
I then will call this God my father too,
The great Redeemer of a fallen race
Who deigned in pity and in love to lay
His royal splendor by, and take upon
Himself the burden of a guilty world.
In human nature's humble garb he comes
To bring the lost ones of this lovely earth
Back to their native Paradise and Heaven.
He bore the guilt of all men on the Tree,
And rose triumphant o'er the grave and death,
To offer pardon even to the worst
Of Adam's fallen, wretched, ruined race.
And now he stands in meekness all arrayed
Holding the golden crown of righteousness
To place upon the brow of those who come,
A crown, to glitter, when the crowns of kings
Shall fade away,—when earth shall stop its course,
And sun, and moon, and stars are blotted out—
When the last trump shall sound, and kingly saints
Shall meet their blest Redeemer in the skies.

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GLOSSARY

OF MINERALS, GEMS, AND DEFINITIONS OF TERMS IN GEOLOGY AND MINERALOGY.

Abnormal, development of structure or form contrary to regular law.

Actynolite, color green of various shades; lustre shining, and sometimes glossy. One-half silica with magnesia, alumina, lime, oxide of iron, chrome, manganese, potash, and water. Brittle, bladed and other varieties occur in talc.

Acrogens, plants that grow from their summits, as mosses and ferns.

Acicular, long and slender crystals; from the Latin, a needle.

Acuminate, coming to a long point.

Adularia, a variety of felspar of pearly lustre, reflecting various colors, and is sometimes named *moonstone*.

Affinity, force by which elements combine.

Aggregate, many kinds in one mass, as in pudding-stone, granite.

Agalmatolite, a variety of soapstone containing potash, lime, alumina, silica, and water.

Agaric mineral, rock milk, a variety of spongy marble.

Agate, an aggregated variety of quartz.

Alabaster, compact, translucent gypsum, or limestone; a drop of acid will effervesce on the limestone but not on the gypsum.

Albite, is felspar containing soda instead of potash.

Algæ, sea-weed of lowest order.

Albin, an opake white crystalline, laminated earthy mineral.

Allanite, a rare mineral in granite of greenish and yellowish

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brown color, composed of oxide of cerium, oxide of iron, lime, silica, and alumina.

Alloy, a combination of two or more metals.

Alluvial, washed or brought together by the action of water.

Almandine, precious garnet.

Alum, sulphate of alumina and potash. The artificial is composed of *alumina*, *sulphuric* acid, *potash* and *water*, and is made by heating the alum stones in a wood fire and throwing them into water while hot. The water is boiled and allowed to crystallize.

Alum slate, color blue, green or iron black. Composed of silica, sulphur, carbon, alumina, lime, iron, potash and water. Lebanon Springs, N. Y.

Alum stone, color grey, brown or reddish white; found near volcanoes.

Alumina, the base of alum and is not found pure in nature, but is found in soil and alum rocks, united with sulphur or other ingredients.

Amalgam, a combination of mercury with other metals.

Amber, a fossil vegetable resin, yellow, or greenish brown, occurring in nodules of various sizes, electric by friction, and shining with a resinous lustre. In Prussia a mine of amber is found under a stratum of trees, partly decomposed and fifty feet in depth. Some specimens have been found near Trenton, N. J., in lignite.

Ambligonite, greenish white in rhombic prisms, containing lithia, alumina, phosphoric and fluoric acids.

Amethyst, violet quartz, silica, alumina, iron and manganese, found in many places in the United States.

Amianthoid, olive green, fibrous, flexible and elastic, silky and shining, silex, lime, magnesia, iron and manganese.

Amianthus, a variety of asbestos resembling flax or fine silk.

Ammonites, fossil shells that resembled the nautilus.

Amorphous, without form, not crystallized.

Analcime, white, gray, yellow and red. Occurs in primitive and trap rocks. Crystallizes in cubes. Composed of silica, alumina, soda, lime and water. Found near Paterson, N. J., in greenstone.

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Anaalusite, purplish red; scratches quartz, hardness and specific gravity, greater than felspar. In primitive rock, alumina, potash, silex, oxide of iron. Found in Andalusia in Spain, in France, Saxony, Ireland, United States.

Angle, point or corner where two lines meet.

Anhydrite, a variety of gypsum that contains no water of crystallization.

Anhydrous, without water.

Anthracite, color grey or jet black, shining with metallic lustre, often with various colors, composed of nearly all carbon, with a small portion of alumina, iron and silica.

Anticlinal axis, dipping of strata in opposite directions.

Antimonial silver, a rare mineral found with the ores of silver.

Antimony, silver white, lustre shining, found in crystals and thin plates, in Harwinton, Connecticut, with sulphuret of antimony.

Apatite, phosphate of lime, various pale shades, translucent, vitreous, yields to the knife, found in primitive rock with garnets, quartz, fluor, iron and other minerals, composed of nearly equal portions of phosphoric acid and lime. In New Jersey and other states.

Aphrite, a soft pearly variety of carbonate of lime, in cavities.

Aplome, a dark brown variety of garnet.

Apophyllite, rose, green or brownish white, luster shining, transparent or nearly so, structure like selenite. One half silica, one-fourth lime, potash and water.

Aragonite, a species of carbonate of lime, translucent in crystals, green, gray and yellowish white · first found in Aragon.

Arborescent, to grow like a tree.

Arenaceous, full of sand.

Argentine, color white, sometimes reddish or light gray, in thin curved plates, translucent, a soft variety of carbonate of lime.

Argillaceous oxide of iron, bluish gray and brown, earthy fracture and yields to the knife, common in secondary rocks, iron, alumina, silica and carbonic acid, carbonaceous matter and lime.

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Argillaceous, consisting of clay.

Arsenic, gray, yields to the knife brittle; found in primitive rock with oars of cobalt, silver and other metals. In its pure state it is said not to be poisonous, but deadly in all its mixtures.

Arseniate, a mineral united with arsenic acid.

Articulated, jointed.

Articulator, second branch of the animal kingdom.

Asbestos, white, and various shades of gray, yellow and green, fibres, translucent and shining; found in serpentine, silex, alumina, magnesia, lime and oxide of iron.

Asparagus stone, transparent, shades of green crystals only, over one-half lime and phosphoric acid.

Atolls, coral islands with a lagoon in the center.

Atom, simple element.

Augite, dark green, brown and yellow, gray and white, luster glimmering, occurs in crystals and amorphous, in primitive rock and composed of silica, lime, magnesia, oxide of iron and manganese.

Automolite, a gem of dark green color, composed mostly of alumina and oxide of iron with silex.

Axis synclinal, dipping of the strata towards each other.

Azulite, beautiful blue translucent crystals, more than one-half alumina, with lime and magnesia and oxide of iron.

Barytes, a poisonous mineral, never found pure in nature, and is obtained from the sulphate or carbonate. One species is found in Missouri lead mines, composed mostly of sulphate of barytes with a small proportion of lime, alumina and oxide of iron, used for paint.

Basalt, dark gray, brown and bluish black; fracture coarse grained and uneven. It is sometimes porphyritic containing quartz, hornblende and other mineral substances, composed of silica, alumina, lime, magnesia, soda, oxide of iron and water.

Basin, a depressed area with strata dipping inwards.

Base, a mineral to which an acid is united.

Bed, a layer of rock of uniform character.

Beryl, color various shades of pale green, in six-sided pyramid

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crystals. It is a variety of the emerald, of paler color and composed of over one-half silica, with alumina, glucine, lime and oxide of iron.

Bismuth, a metal found pure and as an oxide and sulphuret; color silver white with a copper tinge, found in quartz, gneiss and mica-slate.

Bitter spar, or rhomb spar, yellow or gray white, a crystal of magnesian limestone composed of nearly equal portions of carbonate of lime and carbonate of magnesia, with a small quantity of oxide of iron.

Bitumen, mineral pitch.

Bituminous shale, found in coal regions and contains impressions of fish, ferns, leaves, and reeds in different layers.

Bituminous wood, (*fibrous lignite*), dark brown texture resembling wood; brittle and light. Specimens are found having mineral coal on one side and knots of wood on the other.

Bladed, with long flattened fibres aggregated like the blade of a knife, as in tremolite.

Black coal, burns with flame and smoke, and composed of carbon, hydrogen, azote and oxygen.

Black lead, carburet of iron, gray or black, occurring in masses, or disseminated in other minerals. The finest is called graphite, and is sawed into grooves of wood for lead pencils.

Black oxide of manganese, gray, purple or iron black, occurs massive, acicular, fibrous and radiating; one-half oxygen, and when mixed with salt and sulphuric acid, forms bleaching powder.

Blende (*sulphuret of zinc*), many shades of dark brown, brittle, crystallizes in rhombic prisms, grouped and shining; becomes malleable at two hundred and twelve degrees; with copper, it forms brass. Hydrogen is obtained by dissolving zinc with sulphuric acid and water.

Blue carbonate of copper, various shades of blue, and found massive, disseminated and crystallized, and composed of oxide of copper, carbonic acid and water.

Bole, a fine clay, colored red and brown by iron.

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Borate of lime (datholite), green and grayish white, massive and crystallized. Lime, boric acid and water, translucent.

Borax (borate of soda), composed of soda, boric acid and water, and procured from a lake in Thibet, which is supplied by springs.

Botryoidal, hung with clusters.

Botryolite, red, yellow and grayish white, fibrous and earthy; in concentric layers; lime, boracic acid, water and silex; found at Passaic Falls, N. J.

Boulders, fragments of rock rounded by attrition.

Breccia, broken angular pieces of any mineral cemented by same or other mineral.

Brittle, not malleable.

Brucite, yellowish brown or amber, translucent, fracture uneven; one-half magnesia, with silica, potash, alumina and oxide of iron.

Bucholzite, black and white, glassy or waxy; the black is fibrous; one-half alumina, silex and oxide of iron.

Cacholong, a variety of chalcedony, milk white.

Cadmium, a tin, white metal, sometimes found among the ores of zinc.

Calamine, a carbonate of zinc.

Calamite, a huge fossil vegetable, also a variety of fibrous tremolite; color light green; found in many places in magnesian limestone or dolomite. (Sheffield, Mass.)

Calcareous spar, color gray, red and yellowish white; forms of crystals, numerous; beautiful pale yellow specimens come from Bermuda Islands.

Cambrian, lower silurian system.

Cannel coal, a species of coal of fine, compact texture, used for candles in England and Scotland. The strata that cover coal is argillaceous slate and sandstone of secondary rock formation, and contains vegetable impressions. Sticks and logs of pure charcoal are found, sometimes part mineral and part charcoal, giving decided evidence of their vegetable origin.

Canaliculated, channeled on the surface or covered with crystals.

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Carboniferous, a system of rocks containing beds of coal.

Capillary, a hair-like appearance of some textures of minerals.

Carapace, the shield that covers the back of a crustacean.

Carbonate, a mineral in which carbonic acid is combined with a base.

Carbonate of lime, color usually gray or white, but assuming a variety of colors in the marbles; composed of lime and carbonic acid.

Carbon, a simple substance.

Carnelian, a variety of rose quartz, named from its resemblance to flesh.

Cats-eye, a crystal of quartz imported from India.

Cavernous, a mineral in which are hollows and cavities, is said to be cavernous.

Cellular, containing small cells and cavities.

Celestine sulphate of strontian, two varieties, fibrous and foliated; a four-sided prism, with two-sided summit; colors gray, white and blue. The carbonate of strontian is greenish white, brittle; prism hexahedral.

Cerium silicious oxide, a rare metallic mineral, various shades of brownish red, with compact fracture.

Cetacea, marine mammals, as whale, porpoise, etc.

Chabasie, white, yellow, gray or pale red crystals, found in basalt and greenstone; rhomboidal or cube.

Chalcedony, of various shades, translucent, and harder than flint, occurring in small masses, nodules and hollow crusts. It is generally milky or cloudy, and composed wholly of silica and alumina.

Chalk, a soft carbonate of lime, forming hills in England. It is of secondary formation, and contains shells and nodules of flint, from which gun flints are made.

Charcoal (mineral), has various proportions of earth and iron, with texture like wood; black, with glimmering lustre, and heavier than charcoal. It is found in thin layers, and sometimes attached to bituminous coal. It is entirely without bitumen, and burns without flame or smoke.

Chert, a silicious rock resembling flint.

Chiastolite (macle), a common four-sided crystal, found in

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slaty rock, and composed of silica, alumina and potash. The interior is often darkly shaded.

Chlorite, is of darker green than talc, may be scratched with the nail; found compact, slaty and earthy in primitive rock. The crystals are dark green, six-sided.

Chlorite slate, often abounds with magnetic iron. Chlorite is composed of silica, magnesia, alumina, water, oxide of iron, salt and potash.

Chloropal, green, brittle, translucent on the edges, remarkable for its magnetic properties; rare.

Chlorophane, a variety of the fluate of lime, and curious on account of its emitting an emerald green light when heated in a darkened room.

Chromate of lead, a rare mineral, occurring usually in crystals of beautiful red or orange, composed of oxide of lead and chromic acid.

Chromate of iron, color brownish black, granular or crystallized in four-sided pyramids, and often very highly magnetic; found in serpentine and talc from Philadelphia through several places reaching to Milford, Ct. It is used in the manufacture of chromate of lead.

Chrome, is of tin white, and seldom found pure. The oxide is grass-green or light yellow, with crystalline structure. The gems and other green minerals owe their color to oxide of chrome. A brilliant red is also formed of chromic acid.

Chrysoberyl, a green, massive and crystallized mineral of four and six-sided prisms—nearly transparent, shining, found in granite; composed of three-fourths alumina, silica and oxide of iron.

Chrysolite, a yellowish brownish green, occurring in rounded grains of ten or twelve-sided prisms, one-half magnesia with silica and oxide of iron.

Chrysocolla, color green or blue, composed of oxide of copper, silica, water and carbonic acid, translucent and brittle; found in native copper mines, New Jersey.

Ciliated, furnished with hairs.

(It must be remembered that by analysis, different

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specimens of the same kind of mineral are found to contain different compounds. Example: one specimen of felspar may contain soda, another potash. The silica, alumina, lime, etc., are also variable.)

Chrysoprase, color apple green, glimmering and vitreous, composed mostly of silica with a trace of lime, oxide of nickel, alumina and iron.

Cimolite, a kind of clay earth found on an island in the Archipelago.

Cinnabar sulphuret of mercury, color red or gray, massive and crystals of various rhomboids.

Cinnamon stone, color red, orange or brown red, occurring in masses and fragments, translucent, and composed of silica, alumina and oxide of iron; not very common.

Citrine, a variety of quartz, straw yellow, resembling the topaz.

Clay, most varieties are composed of silica and alumina, sometimes oxide of iron, water, carbon and manganese in small proportions.

Clevelandite, color gray, blue or reddish white in massive or in tabular crystals, slender crystals like fibres are often curved or bent in feathery form. Translucent and scratches glass; composed of three-fourths silica with alumina, soda and lime.

Cleavage, where the fracture separates the mineral into natural joints or regular structure.

Clinkstone, compact felspar.

Cobalt, brilliant gray white when pure, but is not found in nature except as an oxide. It gives a blue tint to paper and linen and colors the paint of china ware.

Coccolite, color reddish brown, greenish or gray black, occurring of different size and shaped grains, often as large as a pea and may be separated by the fingers. A variety of rose color with white augite is found in Philipstown, N. Y., composed of different proportions of the same material as compose hornblende and augite.

Colophonite, color dark shades of green, brown or orange, occurring in grains slightly adhering, composed of nearly

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equal quantities of lime, silex and oxide of iron with alumina and water; found in Willsborough, N. Y., in hornblende rock.

Coherent, a firm union of particles, the opposite of friable.

Columbium, a dark iron gray metal; rare. It scratches glass, amorphous, brittle. Its crystals are imperfectly four-sided and flattened. Its lustre is shining but not metallic, unless rubbed on a rough surface or polished; composed of oxide of columbium and oxide of iron. Found in granite at Haddam and New London, Ct. Discovered in 1801 and sent by Governor Winthrop to the British museum.

Common salt (muriate of soda), in its impure state it is of a reddish blue color, translucent, lamellar, crystals in form of cubes. It is sometimes found associated with gypsum, composed of chlorine, hydrogen, oxygen end sodium. *Sea salt, chloride of sodium.*

Compact, when the particles are not discernible and the mineral cannot be divided into regular portions.

Conformable, when the different rocks lie one upon another like the leaves of a book.

Concentric lamellar, circular layers.

Congeneric, belonging to the same species.

Conchoidal, like the shell of a fish, as in compact minerals. It relates only to *fracture*. The material of which the Indian arrows are composed have the conchoidal fracture.

Concretion, a small mass.

Copper, mineralogists give sixteen different species of copper and many varieties. Ferruginous sulphuret of copper is of golden yellow. It occurs in stalactites, amorphous, in concretions and crystals of tetrahedral and other forms, lustre shining; composed of iron, copper and sulphur; a valuable ore.

Corallum, the calcareous part of a polype.

Corundum (adamantine spar), color white and of various dark shades; composed mostly of alumina with silica and iron. It is used to polish other minerals and metals.

Cosmogony, speculative views concerning the origin of the earth.

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Cretaceous, chalky.

Crichtonite, black, in small crystals with truncated summits, lustre metallic; composed of mostly titanic acid, oxide of iron, with silica and a trace of manganese, magnesia and oxide of chrome; found in quartz, in serpentine and in limestone.

Crustacea, articulated animals, as the crab, lobster, &c.

Cummingtonite, color gray; massive and crystalline, lustre pearly; found in mica slate with white iron pyrites.

Cuneiform, wedge-shaped.

Cyanite, see kyanite.

Cycadeæ, a species of fern.

Datholite silicious borate of lime, translucent; composed of lime, silex, boric acid and water.

Detritus (debris), portions of rock borne down by water.

Derbyshire spar (pearl spar), a magnesian carbonate of lime; color white or red, gray or yellowish white, occurring in curved, laminated masses with the crystals partly over each other, giving the mass a scaly appearance. Sometimes the texture is fibrous and lustre pearly. Not common; found in metallic mines with quartz and limestone.

Diallage, color green or greenish white, lamellar, metallic lustre; composed mostly of silica, magnesia, with oxide of iron and water. Found in serpentine. Another species, *green diallage*, has lime in its compound and is translucent, pearly lustre, and scratches carbonate of lime.

Decomposed, when a mineral has lost some of its properties by the action of some other element or elements.

Decrepitate, when a mineral flies off like salt heated in fire.

Dendritic, see arborescent.

Dentiform, shaped like a tooth.

Disseminated, scattered through another kind of mineral.

Diamond, composed of pure carbon. Those that are colorless are said to be of first water. The primitive form is a regular octohedron. Pastael in India affords the best diamonds of the present time.

Diluvium, pertaining to the Noachian flood.

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Disintegrated, fallen to pieces.

Diaspore, a greenish gray mineral, composed of alumina, water and oxide of iron.

Dip, inclination of strata towards any point of the compass.

Dipyre, a reddish white mineral, formed of silica, alumina and lime; found in steatite.

Diverging, when a fibrous structure radiates from a common centre.

Dolerite, a variety of greenstone.

Dolomite, color white, gray or yellowish white, softer than primitive limestone and of slaty texture; composed of carbonate of lime, carbonate of magnesia with a trace of iron and manganese; found in veins with quartz and primitive limestone, in many places in Berkshire, Mass.

Drift, transported beds of gravel, &c.

Drusy, when small, even crystals cover a mineral. Derived from the German.

Dunes, low hills of blown sand.

Dykes, material filling fissures, often projecting like walls.

Earthy, with a texture and fracture like chalk.

Emerald, color bluish green, deeper shade than beryl or tourmaline; composed of silica, alumina, glucine, oxide of chrome.

Emery, color dark bluish gray, composed of ninety per cent. of alumina, with silica and oxide of iron, lustre metallic, reduced to powder in a steel mill; used for cutting gems. It is similar to corundum in hardness and composition.

Encrinite, a radiate with jointed column.

Epidote, a muddy green mineral, found in primitive rock. Crystals grouped, four, six and twelve-sided; scratches glass, fracture uneven, composed of silica, alumina, lime, oxide of iron and oxide of manganese; two varieties. The granular is called scorza. The other is reddish color.

Estuary, bays at the mouth of rivers where the water is only brackish.

Euclase, a green mineral, distinguished from emerald and beryl by its striated crystals.

Eurite, fine crystalline granite.

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Exogens, plants that grow from the outside.

Endogens, inside growers.

Fault, an abrupt displacement of strata.

Felspar, color brilliant white, rose, red, brown, gray and bluish green; structure foliated cleavage in two directions, crystals various and indistinct; scratches glass. Composed of silex, alumina, potash or soda, and sometimes a trace of lime and oxide of iron. Different varieties differ slightly in their composition. It enters into the composition of greenstone and is very slightly diffused in mica-slate, in granite and gneiss it may often be seen in distinct grains. It also forms an important part of syenite and porphyry. In the northern parts of Europe and Asia it forms entire mountains. It is often found loose in fields, hence the name field or felspar.

Flint, color various shades of gray, in nodules coated with chalk. Found in the chalk and limestone formations, also in alluvial deposits in Europe and Asia. Nodules of flint have been found enclosing organic remains, a nail of iron was found in one at Potsham, Prussia, and one hundred and twenty-six silver coins were found in different nodules at Grinoc in Denmark. The fracture is always conchoidal, texture compact, lustre greasy, translucent on the edges, and composed of ninety-eight per cent. silex

Fluate of lime, the crystallized is of every rainbow hue; cleavage in form of the octohedron and other forms. It yields to the knife and corrodes glass, and composed of lime and fluoric acid.

Foliated, like book-leaves, lamellar.

Fossil (dug up), applied to remains of plants and animals in rocks.

Fracture, no regular structure when broken, like quartz.

Frangible, easily broken, quartz is an example.

Franklinite, dark brown or black with deep red lamellar, magnetic composed of oxide of iron, oxide of zinc, oxide of manganese. Found in New Jersey imbedded in red oxide of zinc.

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Friable, susceptible of being crumbled.

Fucoid, a family of fossil plants resembling sea-weed.

Fuller's earth, greenish or bluish white, sometimes other shades, massive; texture earthy, and when thrown into water becomes translucent and falls to powder, composed of silica, water, alumina, magnesia, lime, soda and iron; formerly used as soap.

Galena, sulphuret of lead, crystals, cube and octohedron.

Garnet, all varieties crystallize in form of dodecahedron, composed of various proportions of silica, oxide of iron and alumina, with a trace of manganese.

Gault, blue clay.

Gibbsite, a new mineral of gray or greenish white, fibrous and radiating from the centre, composed of alumina and water.

Gem, ornamental stone, as sapphire, diamond.

Gold, a pure metal in its native state, usually found in quartz rock.

Genus, a group composed of allied species.

Geode, a hollow ball lined with crystals of quartz or amethyst. The balls are sometimes agate.

Glaciers, vast accumulations of snow or ice in Alpine regions.

Glance, shining.

Gneiss, semi-stratified granite.

Granite, a compound of quartz, mica and felspar.

Granular, composed of coarse or fine grains.

Greasy, lustre of some kinds of quartz.

Greenstone, a sort of trap rock, older than the basalt of Europe.

Green earth, a variety of chlorite, composed of silica, potash, oxide of iron, magnesia and water.

Grits, angular grained quartz.

Gypsum (sulphate of lime), composed of nearly equal proportions of lime and sulphuric acid. Of various shades of rose, red, white, &c., translucent; cleavage in one direction soft. Selenite, alabaster and plaster of Paris are varieties of gypsum.

Gymnosperms, flowering plants with naked seeds.

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Heavy spar (sulphate of barytes), commonly found with the ores of lead, zinc, &c. There are several varieties.

Heliotrope, deep green with red and yellow spots, translucent on the edges, composed of eighty-five per cent. silica with alumina and oxide of iron.

Hematite (fibrous red oxide of iron), color brownish red and steel gray, stalactical, fibrous or compact; composed of ninety per cent. of iron, with silex, lime and water. The compact variety is found with the fibrous and other iron ores in both primitive and secondary rock.

Heulandite (foliated zeolite), usually white, translucent or transparent, with pearly lustre, brittle; composed of silica, alumina, lime and water.

Hornblende, bottle green or black; structure slaty, crystallized or massive crystals, aggregated in confused masses in form of rhombic or six-sided prism, opake fracture, foliated or fibrous, yields to the knife. Schorl is much harder than hornblende and has nine-sided crystals. Hornblende is tougher and softer than augite and composed of nearly the same chemical elements. In Brunswick, Me., crystals occur in white granular limestone. At Franconia, N. H., and Jericho, Vt., it is found in serpentine rock. It enters largely into the composition of syenite, and greenstone, and often found in mica-slate, granite and gneiss. Mountains in Siberia occur of hornblende with granite veins.

H. O., chemical symbols for water, hydrogen and oxygen.

Homology, relations in type of structure.

Hornstone, brighter and not as hard as flint; fracture conchoidal; composed of silex, alumina, iron and a trace of lime; found in veins in primitive rock.

Humus, vegetable mould.

Hyacinth, a gem of yellowish red; composed of zirconia, silica and oxide of iron, found in primitive rocks and in the beds of rivers.

Hydrate of magnesia, white, soft, in thin plates; composed of magnesia and water. Found at Hoboken, in serpentine rock.

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Hypersthene, see Labrador hornblende.

Hypozoic, below life, as mica-slate, gneiss, &c.

Hydrate, a mineral substance combined with water.

Ichnology, the science that treats of footprints of extinct animals.

Imbedded, quartz are sometimes imbedded in marble and other minerals, and the rock in which the mineral is imbedded, the Germans call *gangue*. Quartz is the *gangue* of gold.

Idocrase, yellowish green, transparent or translucent, scratches glass; composed of silica, alumina, lime, oxide of iron; found in primitive and volcanic rock.

Igneous rocks, rocks that have been acted upon by fire.

Iridium, a metal harder than platina and of lighter color.

Iron (native), pale gray. Many species and varieties. The sulphuret is very beautiful, crystals of every form and color. It is often taken for gold. It may be distinguished from gold by not being malleable, and from copper by not yielding to the knife. Iron pyrites emit the odor of sulphur.

Irised, colored like the rainbow.

Jade, a beautiful green, compact mineral of various shades of green or blue; very difficult to break, translucent on the edges, scratches glass; composed of silica, lime, soda and potash.

Jasper, of various shades of brilliant colors, opake; composed of silica and iron.

Jeffersonite, a dark green mineral, found imbedded in Franklinite, in New Jersey.

Jet, found in the coal formation, often in form of a branch of a tree, compact, shining, opake.

Joints, lines lying obliquely to the bedding planes.

Kaupholite, white and crystallized in rhombic tables. It is a variety of prehnite, and found chiefly in secondary rock.

Kaolin (china clay), decomposed felspar.

Kyanite, color azure blue, occurring in distinct and in aggregated crystals; composed of alumina, silica and iron; found in granite in many places.

Laminated, divided into thin plates.

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Lava, various shades of brownish black, heavier than pumice, not fibrous.

Lead, color bluish gray; found in granite and as high in the series as the lias; the sulphuret is most common.

Lamellar, in thin plates.

Lias, argillaceous limestone.

Lenticular, flat and convex on both sides.

Lepidolite, color lilac, pearl gray or red, in shining scales like mica.

Lignite, carbonized wood, brownish black; composed of carbon, water and oily bitumen. Branches of trees little changed are found among it.

Lime, this mineral is generally combined with some acid forming limestone, gypsum, &c. It forms one-fourth of the earth's crust.

Loam, a material of which soil is formed; consists of silica, clay, lime, alumina, water, iron, mica, &c.

Lustre, is light reflected from the mineral, and is always the same in the same species; vitreous, pearly, metallic, &c.

Madrepore, a family of corals with star-shaped cavities.

Magnesia, a white, earthy mineral; sometimes found pure but generally combined with other substances.

Malachite, green carbonate of copper.

Manganese, a dark, iron colored mineral, massive and crystallized, often radiating from a point in form of needles, soils the fingers; some varieties contain iron, silica, carbon, barytes, &c.

Malleability, susceptibility of being extended by the hammer.

Mammillated, a surface with rounded projections.

Marble, pure carbonate of lime, lime or calcium 57, carbonic acid 43.

Massive, not having any regular external form, yet possessing regular internal structure.

Melaphyre, black augite with imbedded crystals of felspar.

Mercury, silver white, found pure in small, liquid globules in limestone and in sandstone.

Metamorphic rocks, those which have been altered since they were consolidated.

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Medial, passing along the middle.

Mica (isinglass), from the Latin, *mico*, to shine; white and many shades of smoky brown, bluish yellow, &c., structure foliated; composed of silica, alumina, potash, with a trace of manganese and water. It is found disseminated in mica-slate, in granite, and in large masses.

Mica-slate (mica-schist), a stratified rock composed of quartz and mica, irregularly and coarsely blended.

Mineralogy, science of minerals.

Mocha-stone, moss-agate, translucent, with the appearance of internal vegetation. Found in many places, in United States.

Mollusca, animals with soft bodies in a shell, as clams and oysters.

Molybdena, a metal generally found as sulphuret or oxide.

Mountain limestone, the lowest beds of the carboniferous group.

Mountain cork, a very light variety of asbestos.

Mycology, science of mushrooms.

Naphtha, an oily, inflammable substance, found in the earth; composed of carbon and hydrogen.

Natural joints, when a mineral can be broken into regular forms.

Neptune, in mythology, God of the sea.

Neptunian, formed by water.

Nickel, yellow, gray, reddish and sometimes green, in combination with arsenic and other minerals. It is always found in the meteoric stones.

Nitre (saltpetre), found in grottoes on old walls, under old buildings and in many places in the earth; composed of nearly equal parts of nitric acid and potash.

Novaculite, see whet-slate.

Nodular, in rounded masses.

Octohedron, a solid having eight equal sides; the most common form is that of two four-sided pyramids standing base to base.

Onyx, a variety of chalcedony, white and blue.

Oolite, a variety of carbonate of lime (roe-stone), composed of globular particles the size of mustard seed.

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Opal, a precious stone containing more water than other varieties of quartz.

Opake, admitting no light.

Organic remains, fossils.

Oxide, when mineral substances are united with oxygen.

Oxygen, a simple gaseous body.

Palladium, a metal resembling platina, named from the planet Pallas.

Palœontology, science of fossils.

Pargasite, a variety of hornblende, lighter and more translucent.

Pass-into, flint passes into chalcedony without any distinct mark of gradation; minerals have not distinct marks of gradation.

Pectinated, like a comb.

Petroleum (rock oil), the same as naphtha but less volatile; found in Asia and in United States.

Peroxide, when a metal has the largest quantity of oxygen.

Protoxide, when a metal has the smallest quantity of oxygen.

Prism, when a crystal has four or more sides.

Pinite, a mineral with black or brown crystals, with twelve-sided prisms.

Pitch stone, various shades of dull red, blue, green, brown and black; structure slaty, scratches glass. It is found in primitive and in trap rock, and is of doubtful origin. It sometimes forms the base of porphyry.

Pulverulent, when particles of a mineral are fine and cohere slightly.

Pseudo, a prefix, something false.

Pumice, porous lava.

Quartz, pure white, and every hue of the rainbow; when pure, composed of equal parts of oxygen and silicium, silicon. Silica or silex enters into the composition of all primitive rocks.

Refractory, difficult to break.

Red chalk, red oxide of iron; found in small masses in clay slate and sandstone of recent formation.

Rodentia, animals with two cutting teeth in each jaw.

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Roof slate, color bluish black, found in primitive and secondary rock.

Rotten stone, color reddish or brownish black, fracture earthy and dull, soils the fingers, soft, fetid when scraped; composed of alumina, carbon and silex, supposed to be decomposed shale.

Rubellite (red tourmaline), sometimes found with green tourmaline.

Sahlite, a pale green variety of augite.

Sandy magnetic oxide of iron, color iron black, occurs in crystals and in small grains. It is a valuable ore, sometimes found in gneiss.

Sapphire, various colors, composed of ninety per cent. of alumina and oxide of iron with a trace of lime.

Sard, a red variety of chalcedony (sardonyx).

Satin spar, a translucent variety of carbonate of lime.

Saurians, fossil species of alligator.

Scapolite, various shades of gray or whitish, a variety of Wernerite.

Schorl, color white, black, green, blue and yellow, occurs in crystals of six, nine or twelve-sided prisms so truncated as to appear of many faces. It is found in primitive rock, disseminated in crystals; *black tourmaline* is a variety. It is harder than hornblende. Named from Schorlaw in Saxony. It never forms the principal part of a rock.

Schist, a German word signifying slate; schistose structure splits in one direction and is not smooth or regular.

Seam, is a thin layer of rock that separates the strata of another rock.

Sedimentary rocks, deposited by water.

Selenite, crystallized sulphate of lime, many varieties.

Serpentine, various shades of green fracture, splintery and uneven crystals of rhombic form in crystalline limestone in many places; composed of magnesia, silex, oxide of iron, water, lime and alumina.

Shale, is not so hard as argillite and does not split into smooth layers like roof slate. It is often bituminous.

Shingle, the sands and gravel of a sea beach.

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Sillimanite, dark brown, harder than quartz, fracture splintery. Composed of alumina, silica and oxide of iron; found in quartz.

Silt, the finest sand transported by rivers.

Silver, color white or tarnished, usually combined with a little of other metals; found in primitive and secondary rocks. Beautiful specimens are found penetrating crystals of quartz.

Silurian system, named from the rocks of an ancient kingdom on the border of Wales.

Skorza, a variety of epidote.

Soapstone (steatite), various dull shades of gray. It is harder than serpentine and passes into talc, and is found in masses of considerable extent, forming hills composed of silex, magnesia, oxide of iron and water.

Soda (oxide of sodium), usually found combined with acids, forming borax, common salt, glauber's salt, &c.; when pure it is composed of water, soda and carbonic acid.

Sodium, the metallic basis of soda, similar in properties to potassium.

Specific gravity, is the weight of a body compared with an equal quantity by bulk of water.

Sphene, oxide of titanium, color of various dull shades; composed of the oxide with lime and silex.

Spinelle, a species of chrysoberyl, red, crimson, violet, brown and black; scratches quartz.

Spodumene, grayish or greenish white, occurs massive and in crystals, fracture uneven, translucent. It sometimes takes the place of felspar in granite rock; composed of nearly the same material as hornblende.

Spores, productive germs of cryptogamic plants.

Stalactite, hollow tubes or pendulous masses formed on the roofs of caverns from lime water dripping down.

Stalagmite, that which is formed on the floor of the cave. It is often translucent and wrought like alabaster.

Staurotide, color reddish brown, always crystallized in six-sided prisms, united in the form of a cross. This is a most common form. How beautiful to behold the cross

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in the rocks! It is more than half alumina with silex and iron. It is often colored like the garnet, and is found in the varieties of granite rock.

Stilbite, white and various dull shades crystals, a four-sided prism, often slender; composed of silex, alumina, lime and water; found in the fissures of primitive rock and in the greenstone of Connecticut.

Strike, direction of outcrop or line of bearing.

Strontian, is never found pure in nature, but is found united with sulphuric and carbonic acids.

Sulphur, native color yellow, often tinged with orange, green and gray. It is found in veins of rock, but chiefly in ancient volcanoes. It exists in mineral waters, and is combined with ores and many minerals.

Sulphuret, when sulphur is united with a metallic base.

Sulphate, when the sulphuric acid is united with an earthy base.

Syenite, a kind of granite from Syene, in Egypt.

Tabular, from the Latin, tabula, a table board; slaty or schistose structure; crystals nearly flat are tabular.

Talc, color various shades of green and grayish white, translucent in thin plates and massive; composed of silex, magnesia, potash, iron and water; found in small quantities in granite and serpentine, softer and finer than soapstone.

Tennurium, is found alloyed with other metals, white and gray.

Tennantite, a species of copper.

Thomsonite, white, translucent; a variety of zeolite found in secondary rock.

Tin, white, and easily cut with a knife; found as an oxide and sulphuret.

Titanium, several oxides, some are beautiful red.

Topaz, yellow and various other shades of color; composed of silica, alumina, fluoric acid and oxide of iron.

Tourmaline, see schorl.

Tremolite, color white, or tinged with gray, yellow or red; composed of silica, lime, magnesia, carbonic acid and a

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trace of iron. It resembles asbestos, but is more brittle. It is usually found in limestone or dolomite, in three varieties, fibrous, bladed and crystallized.

Transparent, clear, like common glass.

Trap, igneous rock, often found in the rents of older rocks. Greenstone and basalt are varieties.

Translucent, semi-transparent, like china ware.

Tungsten, a metal found united with other metals in form of an oxide.

Trachyte, signifies rough, or harsh; derived from the Greek. If granite were deprived of quartz it would be essentially trachyte.

Umber, yellowish and dark brown, soils the fingers, falls to pieces in water; composed of oxide of iron, manganese, alumina and water.

Unctuous, refers to talc, soapstone, clay, &c., smooth.

Uranium, this metal is found as an oxide, of dark color, except the green oxide, which is very beautiful, compact and crystalline; found in primitive rock in small quantities.

Wacke (pronounced wakke), a gray mineral resembling basalt, but softer. It may be cut with a knife; near Boston it forms the basis of amygdaloid. It often contains fossils, crystals and petrifactions.

Wernerite, light green or grayish white; it is found massive and crystallized in four or eight-sided prisms; composed of silica, alumina, lime, soda, oxide of iron and manganese. A variety is found at West Point, N. Y., called scapolite.

Wood-tin, fibrous oxide of tin.

Zeolite, white shaded with yellow, red and gray, commonly found in radiated masses in fine and brown crystals, translucent, of silky lustre, and composed of silica, alumina, lime, soda and water; four varieties.

Zinc, is always found combined with oxygen, sulphuric or carbonic acid, which gives it various shades in the ores. It forms brass with copper. It is found associated with lead in the United States.

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Zircon, is of many shades and harder than quartz; found in fragments, grains and crystals, and composed of zirconia, silex and oxide of iron; found in many places in the United States.

Zoophytes, corals, sponges, &c.

Zoisite, a species of wernerite.

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TESTIMONIALS.

THE following are some of the TESTIMONIALS which the author has received:

From Hon. Joseph White, Secretary of Massachusetts Board of Education.

"I am wholly pleased with the conception of teaching young pupils the characteristics of the various objects of Natural History and the methods of distinguishing and classifying them. Object teaching is much talked of now-a-days, and often practiced with success as a means of cultivating the perceptive faculties. I know of no more beautiful method of putting object teaching in practice than for a teacher, after having become acquainted with the different specimens of our rocks which your little cabinet furnishes, to present them one at a time to a class of little pupils, and after a careful examination of the single specimen, to send them into the fields and highways to find others of the same kind. This is object teaching to some good purpose. It is beginning the education of children aright. It is learning *things* rather than *words*. I can see the promise of great usefulness in your plan.

"I have called the attention of several teachers and scientific men to your little cabinet, and have heard from all, only expressions of pleasure and approval. I hope you will be encouraged to proceed in perfecting your plan and manual, and am quite sure that they will meet the favor of intelligent teachers and friends of education."

From F. S. Adams, late Secretary Board of Education of Vermont.

"To inspire the young with a wholesome and intelligent love of the Physical Sciences is a glorious work. I wish and expect you abundant success."

From Rev. B. G. Northrup, Secretary of Board of Education of Connecticut.

"Your method of presenting the subjects of Mineralogy and Geology to the young, seems to me, eminently adapted to awaken interest, and to simplify those subjects. I think the children should be early taught to recognize the common rocks and minerals. Properly presented, the study is both useful and attractive.

"I most heartily wish you great success in your effort."

From Mr. J. A. Williams, a teacher in Forkland, Ala.

"I have been reading your book with much interest, and intend studying it thoroughly."

From Miss Emily Nelson of Golden Hill Seminary, Bridgeport, Ct.

"I am much pleased with the manual sent me, and think your system of teaching Geology a good one."

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